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14. ABSTRACT

An acoustical assessment was performed on the Combat Arms Firing Range at Ellsworth AFB in April 2013. It was determined that the noise in the firing range did not meet the definition of impulse noise in AFOSH Standard 48-20 due to acoustical reflections, particularly off the ceiling, side walls, overhead baffles, and floor. Therefore, it was recommended that acoustical absorption materials be added to the ceiling, side walls, and overhead baffles to reduce the reverberant field.

15. SUBJECT TERMS

Impulse noise, impact noise, decay time, CATM, firing range, hearing, acoustics, noise, firearms

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DEPARTMENT OF THE AIR FORCE
USAF SCHOOL OF AEROSPACE MEDICINE (AFMC)
WRIGHT-PATTERSON AFB OH

13 June 2013

MEMORANDUM FOR 28 MDOS/SGOJ
ATTN: CAPT MCCLELLAN
2900 DOOLITTLE DR
ELLSWORTH AFB, SD 57706

FROM: USAFSAM/OEC
2510 Fifth Street
Wright-Patterson AFB, OH 45433

SUBJECT: Consultative Letter, AFRL-SA-WP-CL-2013-0013, Acoustical Evaluation of Combat Arms Firing Range, Ellsworth AFB, South Dakota

1. INTRODUCTION:

a. *Purpose*: On 8-12 April 2013, the United States Air Force School of Aerospace Medicine, Consultative Services Division (USAFSAM/OEC), at the request of 28 MDOS/SGOJ, conducted an acoustical evaluation of the 28 SFS/S3C, Combat Arms Training and Maintenance (CATM) firing range facility, bldg 9022, at Ellsworth AFB, South Dakota. The purpose of this survey is to classify the measured noise exposure as continuous or impulse and explain how the classification pertains to AFOSH Standard 48-20, *Occupational Noise and Hearing Conservation Program.*

b. *Survey Personnel*:

(1) Two Bioenvironmental Engineering Technicians, Consultative Services Division, USAFSAM/OECM

c. *Personnel Contacted*:

(1) Flight Commander, Bioenvironmental Engineering, 28 MDOS/SGOJ
(2) Bioenvironmental Engineer, 28 MDOS/SGOJ
(3) NCOIC, Bioenvironmental Engineering Industrial Hygiene, 28 MDOS/SGOJ
(4) NCOIC, Bioenvironmental Engineering Environmental Protection, 28 MDOS/SGOJ
(5) Section Chief, Combat Arms and Armory, 28 SFS/S3C
(6) NCOIC, Combat Arms, 28 SFS/S3C
(7) Combat Arms Instructor, 28 SFS/S3C

d. *Equipment*:

(1) B&K PULSE Analyzer, Type 3560-B-140, SN 2588445
(2) Larson Davis Microphone Pre-amplifier power supply, Type 2221, SN 0203
(3) Larson Davis Microphone, Model # 2530, SN 1492
(4) Larson Davis Microphone Pre-amplifier, Model PRM902, SN 3824
(5) Quest Calibrator, Model # QC-20, SN QF8050050

2. BACKGROUND:

a. The Ellsworth AFB CATM range is a fully enclosed range with 20 total firing stations (see Figure 1). This range is used to train personnel on M4, M9, M240, and M249 weapons firing. A noise reverberant field occurs during firing where the noise energy is reflected off the ceiling, walls, and floor surfaces, thereby increasing noise levels for a longer duration. These noise levels diminish slowly compared to noise levels in free field conditions (i.e., outdoors or indoors with acoustical absorption on the interior surfaces). Down range of the firing line is a series of steel safety baffles on the ceiling that are designed to deflect stray bullets and prevent bullets from leaving the range. These panels are closely spaced, thereby reflecting acoustical energy and increasing the duration of noise levels.

Figure 1. Ellsworth CATM Range Lanes

b. The nonlinear (very large disturbances) acoustical effects from the gunfire peak noise levels, wearing of double hearing protection, and the short-term residual auditory effects from gunfire make it very difficult for students and instructors to communicate. Communication difficulties include understanding instructions and audible warning signals.

c. The maximum level of **continuous noise** that is allowed to reach the ear shall not exceed 115 dBA, and the maximum level of **impulse noise** that is allowed to reach the ear shall not exceed 140 dB peak sound pressure level (SPL) according to AFOSH Standard 48-20.

3. METHODOLOGY:

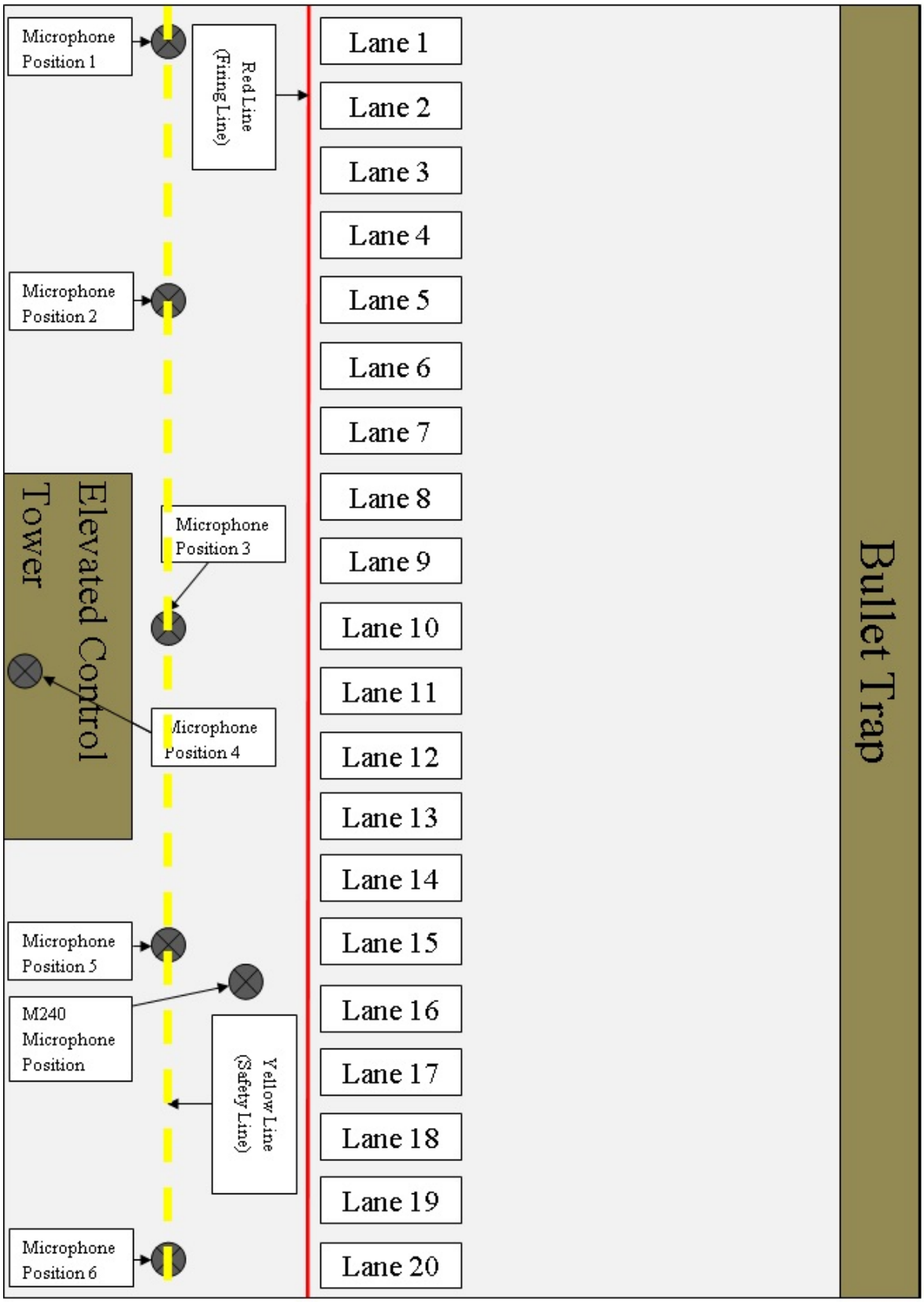
a. *Process Description:* The CATM firing range is used to train and qualify base personnel on multiple weapons systems. The firing range has two distinct painted floor lines that are used for reference (see Figure 2). The first point of reference is the yellow safety line. Students must stand behind this line while not actively firing a weapon. The second point of reference is the red firing line and is located 5 feet forward of the yellow safety line. Students actively fire weapons at a down-range target from the red line. During live-fire weapons training classes, instructors are positioned along the yellow line to ensure the range is safe and to assist students when needed.

b. *Sample Procedure:* The SPL time histories corresponding to individual M4 and M240 weapons firings were measured with a ¼-inch microphone placed 5 feet above ground level along the yellow safety line. Figure 2 illustrates microphone positions. Time histories are measured SPLs over a duration of approximately 4 seconds. This duration provided sufficient time to characterize the decay of the acoustical energy to background levels. These time histories were then used to compute acoustical decay characteristics.

c. The linear SPL decay rates, in decibels per second, were computed by selecting the linear decay phase of each time history and performing a sound level versus time analysis through the decay phase. Decay times are calculated from the linear slope from 150 dB down to 80 dB. The slope of this curve is the decay rate.

d. SPL time history data for the M4 rifle were collected in two phases.

(1) Phase 1 measured noise decay while one CATM instructor fired rounds from each of the following firing lane locations: 1, 5, 10, 15, and 20. During this phase, single-shot noise decay data were collected for three separate shots from each shooter and microphone location combination. For example, the CATM instructor fired three rounds at lane 1 while the microphone was at position 1. After those three shots, the CATM instructor stayed at lane 1 and the microphone was moved to position 2 and three more rounds were fired from lane 1. After data for all six microphone locations were collected for firing lane 1, the CATM instructor moved to the next firing location (lane 5) and the microphone was again rotated through each position (1 – 6). This entire process was repeated until the CATM instructor had rotated through all five firing lane locations.



(2) The second phase took place during a remedial weapons qualification event. Seven students each shot an M4 from lanes 1 – 5, 7, and 8. Data were collected by placing the microphone 5 feet above ground level at the yellow safety line at each of the microphone positions identified in Figure 2. A minimum of 10 SPL time histories were collected at each microphone position.

e. SPL time history data for the M240 machine gun were collected while four base members separately fired 1000 rounds each between firing lanes 15 & 16. Duing this class, the CATM instructor provided one-on-one oversight to the shooter and was positioned directly to the right of the student, approximately 4 feet away. Therefore, the microphone was positioned as close to the instructor as possible and approximately 4 feet above the ground; see Figure 2 for M240 microphone position.

4. RESULTS:

a. Under the monitored conditions, the noise decay at the Ellsworth AFB CATM range **does not** meet the definition of impulse noise IAW AFOSH Standard 48-20. The definition states that impulse noise is "a short burst of acoustic energy consisting of either a single burst or a series of bursts. The pressure-time history of a single burst includes a rapid rise to a peak pressure followed by a somewhat lower decay of the pressure envelope to ambient pressure, both occurring **within 1.0 second**. A series of impulses may last longer than 1.0 second."

b. The decay time, when averaged over multiple rounds fired and two different types of weapons, was **1.9 seconds**. See Table 1 for a summary of noise characterization and decay times.

Table 1: Noise Characterization by Decay Time

Weapons System	Average Decay Time (s)	Noise Characterization	Maximum **Continuous** Noise Level (dB)	Exceeds Continuous Noise Std. (Yes/No)
M4	1.9	**Continuous**	115	**YES**
M240	1.9	**Continuous**	115	**YES**

5. CONCLUSIONS:

a. Based on the average decay times, the noise in the range is classified as continuous noise. According to AFOSH Standard 48-20, there is no allowed exposure time above 115 dBA. As shown in Attachment 2 of AFOSH Standard 48-20, the peak SPL of both the M4 and M240 is 158 dB. Using a Noise Reduction Rating of 33 dB for dual hearing protection (ear plugs and muffs), instructors and students are exposed to peak SPLs up to 125 dB.

b. Speech intelligibility is poor due to the strong reverberant sound field of the range. This condition increases safety risks.

6. RECOMMENDATIONS:

a. Install sound absorbing material as an engineering control to reduce the reverberant noise field. The reverberant field in the range should be minimized to reduce the noise level to protect instructors and students from hazardous noise exposure and to improve speech intelligibility.

b. Until effective engineering controls can be implemented, close scrutiny to audiograms, as defined in Attachment 1 of AFOSH Standard 48-20, should be considered for CATM instructors, as they **are not** adequately protected in the current range configuration with personal protective equipment and administrative controls.

c. The firing range's first overhead baffle, as well as the ceiling and walls from the red line back, to include the rear wall, should all be treated with acoustical absorption material. Quilted fiberglass, or other fiberglass panels wrapped in a manor allowing easy cleaning, is one option. There are also more fixed installation materials available, such as products offered by Pyrok or Troy Acoustics. There appears to be sound-absorbing material on the walls in the rooms on both sides of the range, as well as above the HVAC baffle on the back wall of the range. This material should **not** be removed if additional sound-absorbing materials are installed.

d. CATM instructors should provide just-in-time training to students on proper use of hearing protection devices as part of classroom instruction. NIOSH has a short video on proper insertion of foam ear plugs available for download at http://www.cdc.gov/niosh/mining/products/movies/rphhi.wmv.

e. Request a follow-up noise assessment after acoustical treatment of the range is complete.

7. If you have any further questions regarding this report, please contact TSgt Jerimiah Jackson at DSN 798-3312 or jerimiah.jackson@us.af.mil. Please direct any questions or comments regarding industrial hygiene consultative support to Maj Eric Sawvel at DSN 798-3328 or eric.sawvel@us.af.mil. To improve our services, please complete the critique located at https://www.surveymonkey.com/s/OECUSTOMERSURVEY.

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